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APPLICATIONS OF MATHEMATICAL PROGRAMMING MODELS IN EDUCATIONAL PLANNING: An Overview and Selected Bibliography

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APPLICATIONS OF MATHEMATICAL PROGRAMMING MODELS

IN EDUCATIONAL PLANNING: AN OVERVIEW

AND SELECTED BIBLIOGRAPHY

by

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During the past few years there has been a rapid development of the field OPERATIONS RESEARCH or MANAGEMENT SCIENCE which should not be confused with the older tradition of SCIENTIFIC MANAGEMENT in the sense of time and motion studies. Management science models that express the organizational environment and its dynamics in mathematical relationships have been applied in the fields of business management, defense analysis, transportation logistics, and more recently in public sector and regional planning. Although the value of these techniques have been demonstrated in the areas listed above, administrators and planning specialists are just beginning to explore the feasibility of adapting these techniques as a means to improve educational planning and decision-making.

The research and bibliography reported here first began as a result of the need for developing an information base or a "state of the art" paper to plan some of the future research in Program HQ: Procedures for Systems Planning, one of the five programs of the Center for the Advanced Study of Educational Administration. This program is designed to investigate the emerging trends outlined above and, more important, the direct utility of operations research and management science models that might be especially suited to the management of instructional programs and to the planning for instructional change in educational organizations.

An earlier version of this research has been used as a part of a presentation on mathematical programming models given at the American Educational Research Association conference pre-session on Operations Analysis Techniques in Educational Planning and Administration in New York City in February 1971. This five day pre-session was jointly funded by the National Science Foundation and the

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American Educational Research Association. This research was subsequently published by this author in the December 1971 issue of the Review of Educational Research under the title of "Mathematical Programming Models in Educational Planning."

The exchange bibliography is based on this article. The review and synthesis for many of the references included in the exchange bibliography can be found in the Review of Educational Research article. However, a number of new references are included here. They are grouped in three sections. The first section deals with the actual educational applications. The second with the related literature in educational planning and systems analysis. The last section includes a few selected general operations research publications that were found in many of the bibliographies of the applications. It also includes those recommended by planners as most useful in this modeling area. This last section will, no doubt, be of particular interest to professors who are responsible for teaching introductory or overview courses in administrative science, planning or operations research where the students come from a wide range of disciplines and have many interdisciplinary interests.

Some major conclusions based on the synthesis of the economics, management, operations research, planning and educational literature on the application of mathematical programming models in educational planning are briefly summarized below:

1. Most applications of mathematical programming models in educational planning have been at the macroeconomic or national levels of educational planning in European, and less developed countries, where investment in education is viewed as a component in aggregate national investment. Several authors suggest that these models might be applied in the United States; however, few reports of this type of activity can be found.
2. Influence of mathematical programming in state and local planning are of more recent origin. At the school district level these models have been utilized to analyze important management considerations regarding noninstructional policies such as transportation, school desegregation, school menu planning and school location and size. These models have made no direct contribution toward analyzing the central tasks of instructional planning, nor have they been considered as a means to develop either a theory of educational planning or a systematic procedure to coordinate present long and short range planning efforts.
3. Development of mathematical programming models for school district planning, in most cases, is conducted in disciplines other than education, i.e., systems engineering, economics, business administration, industrial management and operations research. The value of the models found in the literature

could be greatly enhanced and made more general if educational researchers and school executives would assist model builders to interpret the realistic nature of their model assumptions in light of the organizational characteristics of schools.

4. Based on the identified need for more effective communication between school executives and operations research specialists as a first step toward improving the utility of mathematical models in future educational planning efforts, a set of guidelines should be developed to evaluate this interaction over time between decision makers and technical specialists as they move toward agreement on decision criteria, operational variables and organizational constraints in each phase of planning. The extent to which other public sector organizations have resolved various modeling and planning problems similar to those encountered in educational organizations should be identified and disseminated to educational planners.

Based on the review of applications, the following criteria in the form of questions should provide planners and managers with some insight to evaluate operations research models reported in the literature, and also to assess the utility of decision models that might be proposed in connection with some future planning or policy analysis in the educational as well as other public sectors.

1. What is the single system to be modeled?
2. Should a unique model be built for each subsystem?
3. Who are the decision-makers? What assumptions are made about the decision-maker who would use the model?
4. Who is responsible for the generation of alternatives? How are they developed and by what criteria are they compared?
5. What are the goals, overall objectives or targets involved? What is their purpose?
6. Are priorities or weights involved? What is their purpose?
7. Are performance and effectiveness involved? How are these concepts defined and how are they measured?
8. What is the pertinent time span for the construction of the model as well as for its implementation once it can be validated?
9. What supportive information systems are required for the model?
10. What are the controllable variables? (For which decision-makers?)

11. What are the uncontrollable variables? (For which decision-makers?)
12. Can multiple criteria be translated to a single figure of merit? Does the concept of optimization vanish without a single criterion?
13. How would you implement the model in its intended environment? Are costs of translating an ideal model to a workable model in the real world prohibitive?
14. How would you teach people to do the things that the model asks people to do?

The following recent quote from the American Association of School Administrator's Commission on Administrative Technology very accurately reflects the interest of many educational administrators and planners in the emerging trends toward investigating the utility of operations research models as a means to improve educational planning that will ultimately effect needed changes and improvements in educational organizations.

NO MAN IS AN ISLAND--AND NO PROFESSION CAN REMAIN
ISOLATED FROM THE FERMENT IN ITS ENVIRONMENT. TO REMAIN
A VIABLE FORCE IN EDUCATION, ADMINISTRATORS MUST BE SENSI-
TIVE TO NEW DEVELOPMENTS AND BE CAPABLE OF ADAPTING THE
RELEVANT TECHNOLOGY OF THIS ERA TO THEIR TASKS.

This review represents one small step in this direction. The recent work of the AASA Commission on Administrative Technology has been published and can be found in Section Two of the references under the name Stephen J. Knezwich, the publication editor.

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